TWO SCALE MODELING OF PLAIN WEAVE COMPOSITES WITH REINFORCEMENT IMPERFECTIONS

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It is a well-understood and widely accepted fact that an overall response of composite structures is influenced equally by the material behavior and geometrical arrangement of distinct phases taking place on different length scales present in the analyzed structure. For example, the effective behavior of woven composite materials is driven by both the disordered microstructure on the level of individual constituents, referred to as *microscale*, and the waviness, misalignment and nonuniform cross-sectional aspect ratio of individual tows on the *mesoscale* level observed in real microstructures.

In this regard, the formulation of a reliable and accurate geometrical and numerical model is of paramount importance. Note that idealized models of geometry, which do not account for reinforcement imperfections, are not valid even for carefully prepared laboratory samples. It thus appears inevitable to replace such models with a geometrical model, which is still simple and computationally attractive, but yet reflects, at least to some extent, the real geometry of a composite.

A number of different techniques can be used to accomplish this task ranging from simplified engineering models to stochastic fully coupled modeling where the whole structure with all significant details is simulated. In this contribution, we present a combination of two geometrical modeling approaches, based on the microstructural statistics, implemented within the uncoupled multiscale analysis framework.

On the microscale level, the overall response is estimated by the Hashin-Shtrikman variational principles extended by including eigenstrain and eigenstress fields to account for the presence of initial strains in the matrix. The random character of the fiber distribution is incorporated directly into the variational formulation employing two-point probability functions.

The mesoscale strategy relies on the notion of the statistically optimized periodic unit cell (PUC) which is derived by matching material statistics of a target microstructure, obtained for a twodimensional section(s) of a three-dimensional microstructure, and the statistics related to an idealized PUC. Following recent works on reconstruction of disordered media, the objective function appearing in the optimization problem is defined in terms of the two-point probability function, the lineal path functions or the combination of both, respectively.

Results of this analysis are presented for the graphite fiber/polymer matrix plain weave fabric composite system. The generalized compressible Leonov model is introduced to describe the nonlinear behavior of the matrix phase while the fibers are assumed to remain elastic during the loading process. The effect of anisotropy on microstructural level on overall response is also addressed.